CLAIMS

1. A high-strength hot-dip galvanized steel sheet characterized by:
containing, in weight,
C: 0.03 to 0.25%,
Si: 0.05 to 2.0%,
Mn: 0.5 to 2.5%,
P: 0.03% or less,
S: 0.02% or less, and
Al: 0.01 to 2.0%,
with the relationship among Si, Mn and Al satisfying the following expression,
$Si + Al + Mn \geqq 1.0\%$;
a hot-dip plating layer being formed on each of the surfaces of said steel sheet; and
5 to 80 % of the surface area of said steel sheet being occupied by oxides when said steel sheet surface is observed with a scanning electron microscope after a hot-dip plating layer is dissolved by fuming nitric acid.

2. A high-strength hot-dip galvanized steel sheet according to claim 1, characterized by further containing, in weight, one or both of
Ni: 0.01 to 2.0% and
Cr: 0.01 to 0.5%.

3. A high-strength hot-dip galvanized steel sheet according to claim 1 or 2, characterized by the oxides on said steel sheet surface containing one or more of Si, Mn and Al.

4. A high-strength hot-dip galvanized steel sheet according to claim 2, characterized by further containing, in weight, one or more of
Mo: 0.01 to 0.5%,
Cu: 0.01 to 1.0%,
Sn: 0.01 to 0.10%,
V: less than 0.3%,
Ti: less than 0.06%,
Nb: less than 0.06%,

B: less than 0.01%,

REM: less than 0.05%,

Ca: less than 0.05%,

Zr: less than 0.05%, and

Mg: less than 0.05%.

5. A high-strength hot-dip galvanized steel sheet characterized by, when said steel sheet contains retained austenite and only Mo is added among the elements stipulated in claim 4:

the relationship among Si, Al and Ni satisfying the following expressions,

$0.4\ (\%) \leqq Si\ (\%) + Al\ (\%) \leqq 2.0\ (\%)$,

$Ni\ (\%) \geqq 1/5 \times Si\ (\%) + 1/10 \times Al\ (\%)$, and

$1/20 \times Ni\ (\%) \leqq Mo\ (\%) \leqq 10 \times Ni\ (\%)$; and

the volume ratio of said retained austenite in said steel sheet being in the range from 2 to 20%.

6. A high-strength hot-dip galvanized steel sheet characterized by, when said steel sheet contains retained austenite and Cu or Sn is further added in addition to Mo among the elements stipulated in claim 4:

the relationship among Ni, Cu and Sn satisfying the following expression,

$2 \times Ni\ (\%) > Cu\ (\%) + 3 \times Sn\ (\%)$;

the relationship among Si, Al, Ni, Cu and Sn satisfying the following expression,

$Ni\ (\%) + Cu\ (\%) + 3 \times Sn\ (\%) \geqq 1/5 \times Si\ (\%) + 1/10 \times Al\ (\%)$; and

the volume ratio of said retained austenite in said steel sheet being in the range from 2 to 20%.

7. A method for producing a high-strength hot-dip galvanized steel sheet characterized in that the volume ratio of retained austenite in said steel sheet is in the range from 2 to 20% and a hot-dip galvanizing layer is formed on each of the surfaces of said steel sheet by

subjecting a steel sheet satisfying the component ranges stipulated in claim 5 or 6 to the processes of: annealing the hot-rolled and cold-rolled steel sheet for 10 sec. to 6 min. in the dual phase coexisting temperature range of 750°C to 900°C; subsequently cooling up to 350°C to 500°C at a cooling rate of 2 to 200°C/sec., or occasionally heat retention for 10 min. or less in said temperature range; subsequently hot-dip galvanizing; and thereafter cooling to 250°C or lower at a cooling rate of 5°C/sec. or more.

8. A method for producing a high-strength hot-dip galvanized steel sheet characterized in that the volume ratio of retained austenite in said steel sheet is in the range from 2 to 20% and an alloyed hot-dip galvanizing layer containing 8 to 15% Fe is formed on each of the surfaces of said steel sheet by subjecting a steel sheet satisfying the component ranges stipulated in claim 5 or 6 to the processes of: annealing the hot-rolled and cold-rolled steel sheet for 10 sec. to 6 min. in the dual phase coexisting temperature range of 750°C to 900°C; subsequently cooling up to 350°C to 500°C at a cooling rate of 2 to 200°C/sec., or occasionally heat retention for 10 min. or less in said temperature range; thereafter hot-dip galvanizing; subsequently heat retention for 5 sec. to 2 min. in the temperature range from 450°C to 600°C; and thereafter cooling to 250°C or lower at a cooling rate of 5°C/sec. or more.

9. A method for producing a high-strength hot-dip galvanized steel sheet characterized by subjecting a steel sheet satisfying the component ranges stipulated in claim 1 or 2, before subjecting said steel sheet to hot-dip galvanizing, to treatment in an atmosphere controlled so that: said atmosphere may have an oxygen concentration of 50 ppm or less in the temperature range from 400°C to 750°C; and, when a hydrogen concentration, a dew point and an oxygen concentration in said atmosphere are defined by H (%), D (°C) and O (ppm) respectively, H, D

and O may satisfy the following expressions for 30 sec. or longer in the temperature range of 750°C or higher,

$O < 30$ ppm, and

$20 \times \exp(0.1 \times D) \leqq H \leqq 2{,}000 \times \exp(0.1 \times D)$.

10. A method for producing a high-strength hot-dip galvanized steel sheet characterized by subjecting a steel sheet satisfying the component ranges stipulated in claim 2, before subjecting said steel sheet to hot-dip galvanizing, to treatment in an atmosphere controlled so that, when a hydrogen concentration and a dew point in said atmosphere and an Ni concentration in said steel sheet are defined by H (%), D (°C) and Ni (%) respectively, H, D and Ni may satisfy the following expression for 30 sec. or longer in the temperature range of 750°C or higher,

$3 \times \exp\{0.1 \times (D + 20 \times (1 - Ni\ (\%)))\} \leqq H \leqq 2{,}000 \times \exp\{0.1 \times (D + 20 \times (1 - Ni\ (\%)))\}$.

11. A high-strength hot-dip galvanized steel sheet according to claim 1, a hot-dip galvanizing layer being formed on each of the surfaces of said steel sheet, characterized in that, when a section of said steel sheet is observed with an SEM, wherein the surface of the steel sheet immediately under said hot-dip galvanizing layer is oxidized.

12. A high-strength hot-dip galvanized steel sheet according to claim 1 or 2, characterized in that said steel sheet is further heated and alloyed.

13. A high-strength hot-dip galvanized steel sheet according to claim 1, a hot-dip galvanizing layer being formed on each of the surfaces of said steel sheet, characterized in that, when a section of said steel sheet is observed with an SEM, the maximum length of oxides observed in the surface layer of the base material immediately under said hot-dip galvanizing layer is 3 μm or less and said oxides have gaps between them.